A Census and Mapping of Eight Hectares of Kramer Woods

A Research Report
Submitted to the Faculty
Of Saint Meinrad College of Liberal Arts
In Partial Fulfillment of the Requirements
For the Degree of Bachelor of Science

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INTRODUCTION

Although the northeastern deciduous forest is well known floristically, much remains to be learned about the long-term dynamics of change and equilibrium. The laboratories for such research are the limited remnants of the presettlement forest. It is important to continue recording detailed phytosociological descriptions of these stands. Long term ecological research is valuable for the future assessment of similar stands and the understanding of their growth patterns.

The main characteristic of the northeastern deciduous forest is the predominance of trees with broad leaves and needle leaves that are shed each autumn. The summers are green with life, and the winter is a time of dormant leaflessness. Regionally evergreen trees are also in high percentages in this particular biome. Average rainfall for the area is between 70 cm and 150 cm; the seasonal distribution of rainfall and the length of the growing season favor the dominance of deciduous forests (Braun, 1964).

Detailed forest maps are invaluable tools for discovering trends of change and stabilization within a stand over successive decade intervals. They provide data on the growth and mortality of individual trees and allow for the comparison of species dynamics. They produce a database for testing the theoretical concept of climax. They are also useful in supplementing field experience in teaching sampling methodology.

Using large scale forests maps for teaching sampling methodology provides students with an overview of the entire stand and a more detailed understanding of the spatial relationships (Jackson and Allen, 1967). In a classroom setting students can learn and compare various sampling techniques in a brief period of time. However, this methodology should not replace field experience but merely add to it.

Maps have been prepared for 4 old-growth stands in Indiana assured of ongoing protection. Three have been registered as National Natural Landmarks and dedicated as Indiana Nature Preserves; the fourth, belonging to the city of Terre Haute, has been set aside as a natural area.

The 20.6 ha Davis-Purdue Research Forest in Randolph County was mapped in 1927; the central 8.5 ha was mapped again in 1976 (Parker et al, 1985). In 1954 the central 8.2 ha of the 32.4 ha Donaldson's Woods in Spring Mill State Park was mapped; each decade since then a tree-by-tree comparison has been made (Lindsey and Schmelz, 1964; Schmelz et al, 1975; Barton and Schmelz, 1987). In 1965 4.4 ha of the 25.9 Hoot Woods in Owen County was mapped; follow-up studies were done in 1975 (an additional 2.2 ha were added) and 1985 (Abrell and Jackson, 1977, 1987). Completed in 1976, 3.6 ha of the 42 ha Dobbs Park Natural Area was mapped (Helms and Jackson, 1976).

Kramer Woods is an old-growth, lowland depressional forest in southern Spencer County (Figure 1). Helen Hougland, who owns the 85.8 ha Kramer Woods, inherited the tract from her grandfather, Indiana State Senator Henry Kramer. The only cutting of trees since the mid-1880's was for use in farm buildings. It was placed in classified forest in 1925 and was designated a National Natural Landmark

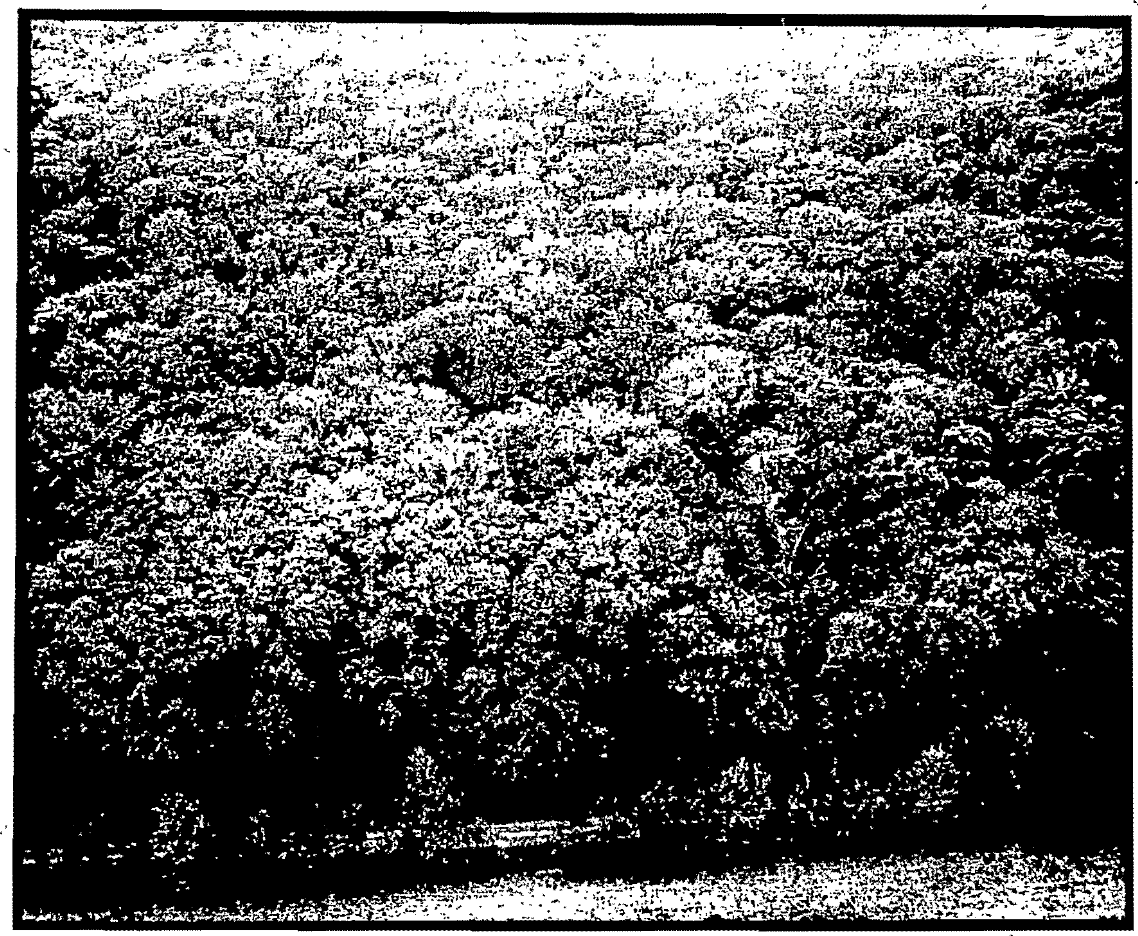

Figure 1. Kramer Woods: Looking south from north edge of the woods.

in 1974. The owner intends that the woods eventually will become the property of the Division of Nature Preserves of the Indiana Department of Natural Resources. Formal dedication as a nature preserve and a plan for its care will ensure that it will be restricted to scientific, educational, and aesthetic purposes. Such actions allow for long term ecological research in protected, undisturbed forests, assuring the preservation of portions of a vanishing ecological biome.

Except for a slope at the northeast corner, the tract is flat, with slight depressions where water ponds after heavy rains. Although the topographic map makes the tract appear to be high floodplain of the Ohio River, the river does not flood it (Figure 2).

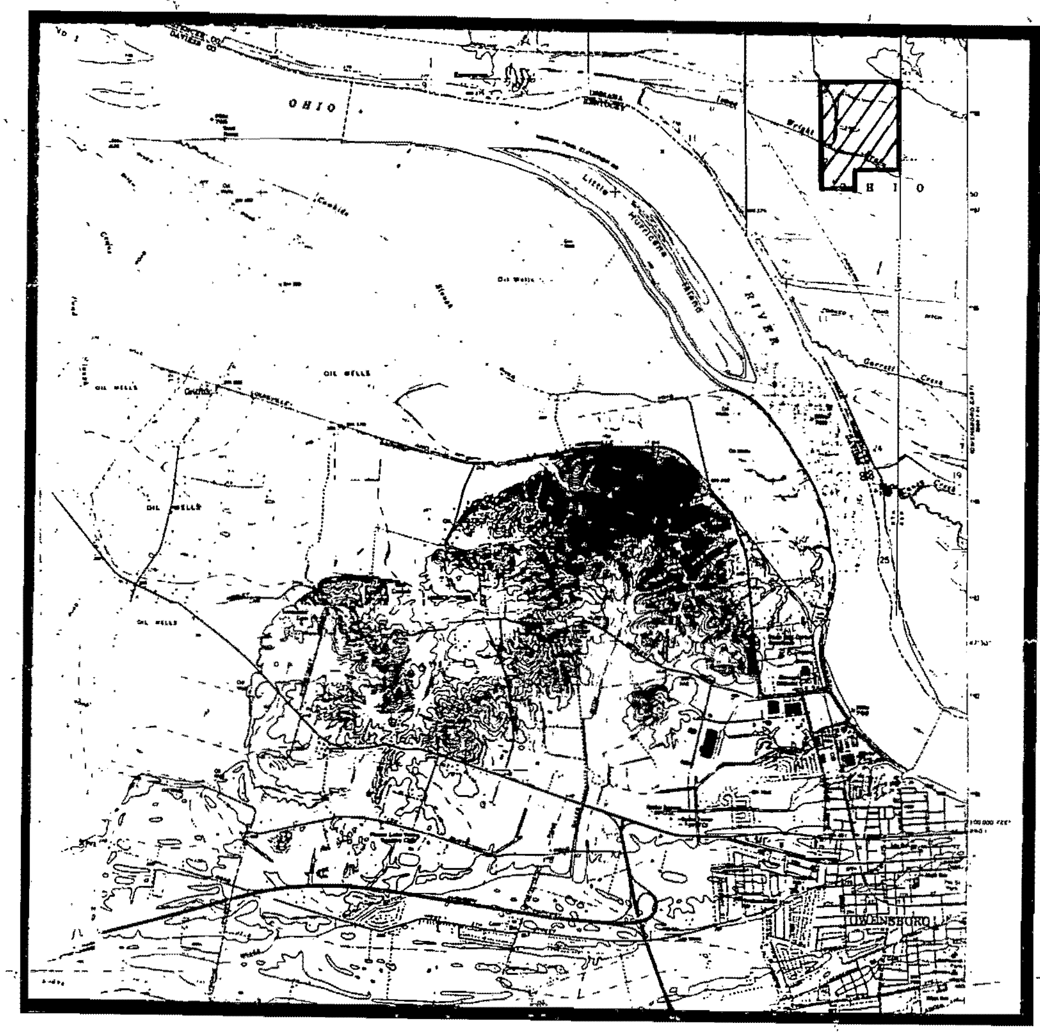

Figure 2. Topographic map showing Kramer Woods, Ohio River, and Owensboro.

The soil maps, show the several soil types in this area dispersed in a crescent moon-shaped pattern corresponding to the natural flow of the Ohio River (Figure 3). It appears that at some time the soil of Kramer Woods was deposited by the Ohio River in flood.

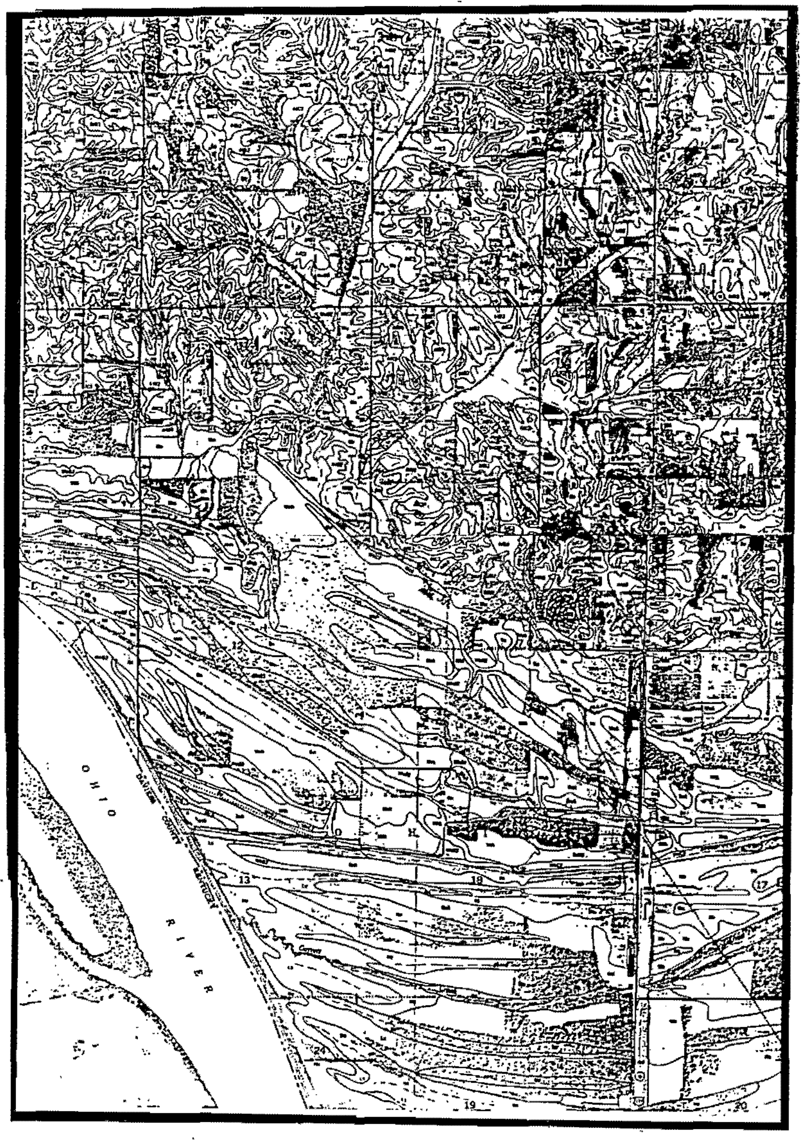

Figure 3. Soil map of the surrounding area.

Kramer Wood's soil type is classified as the Ginat Series (Figure 4).

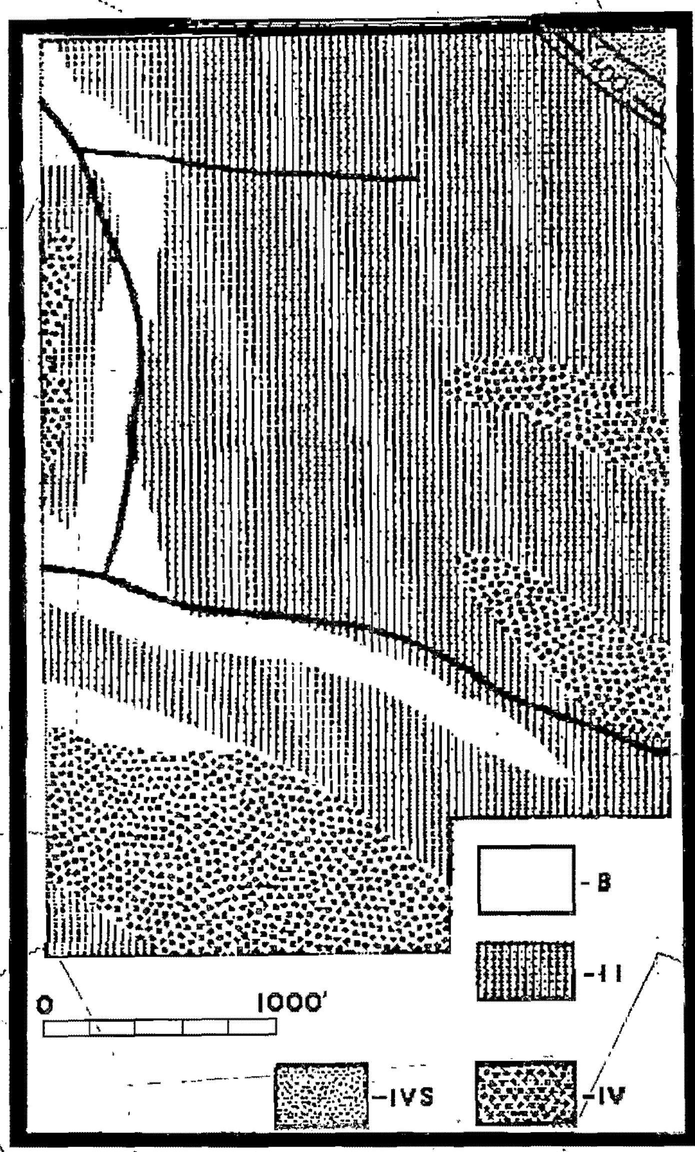

Figure 4. Soil map: B-alluvium; II-Ginat; IV-Woodmere; IVS-Alford.

The Ginat Series is composed of poorly drained, deep, medium textured, practically level soil terraces (0 to 2 % slopes). The soil is low in natural fertility and the organic matter content is low. Permeability is very slow, and the ability to hold moisture is moderate; wetness is a major limitation to use. The surface layer is composed of about a nine inch thick layer of grayish-brown silt loam. Another nine inches deeper in the subsurface layer is a light brownish-gray silt loam that has yellowish-brown mottles. The subsoil, around thirty-two inches thick, is a firm silty clay loam fragipan. At a depth of 65 to 100 inches is a dark-brown silty clay loam and heavy silt loam that is made up of grayish-brown mottles (USDA, 1973).

Hurricane Creek, draining higher land for 3 miles to the north, runs along the western edge. It empties into the east-west Isaac Wright Drain in the lower part of the tract which begins approximately 1.5 miles to the east and joins the Ohio River about 1 mile to the west. The channel to the east was established in 1882 as a legal drain for farm land and is cleaned out periodically. A second smaller east-west ditch about 200 m from the northern boundary drains the farm field along the eastern edge (Figure 5).

In 1967 Schmelz and Lindsey tallied an 8.6 ha section just south of the northern drainage ditch. They judged that it was "far and away the best remaining example of low ground forest type of Southern Indiana." (Lindsey et al, 1969). We were not able to locate the iron stakes marking the corners of the original plot, but the 1967 and 1992 areas certainly overlap.

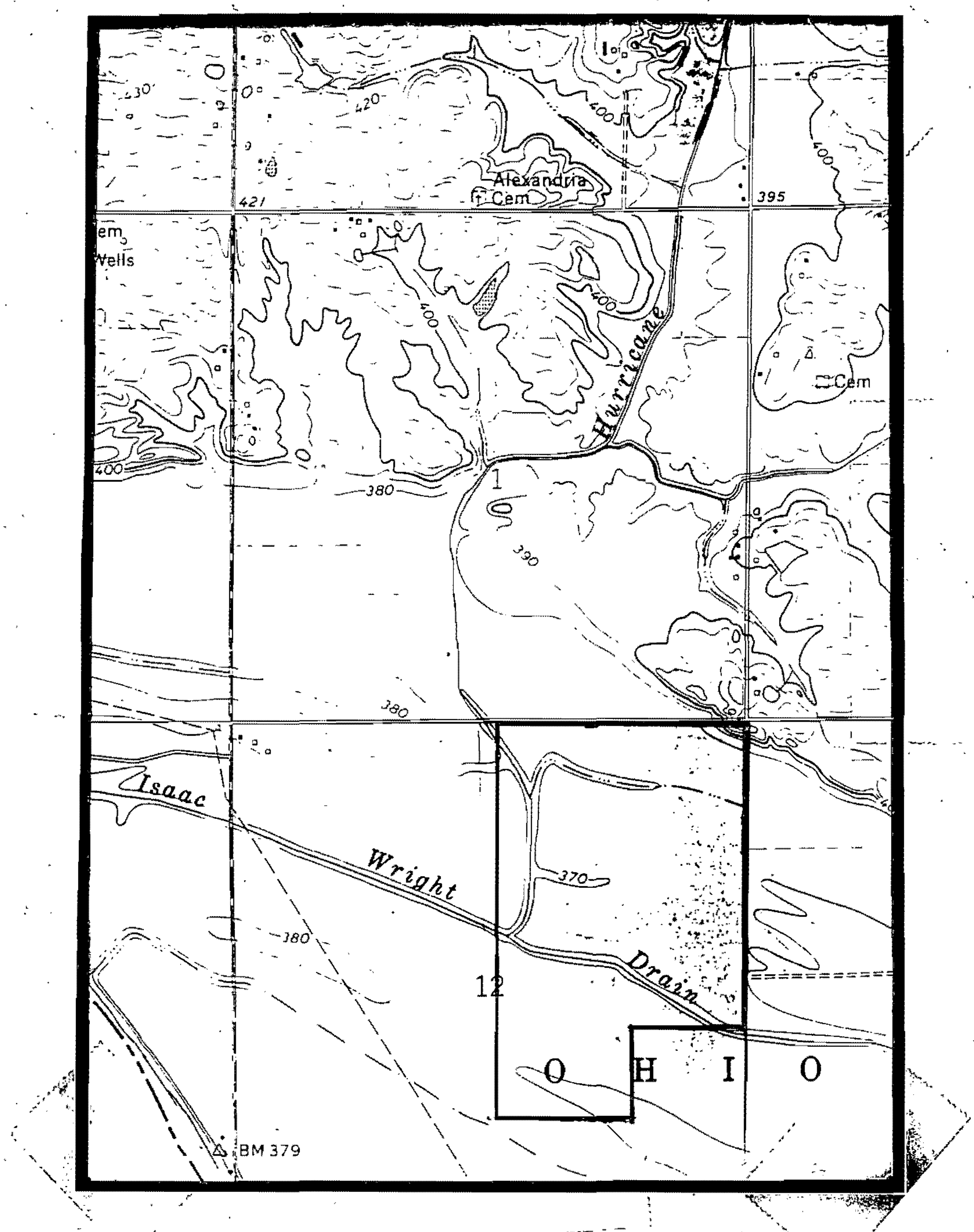

Figure 5. Topographic map showing drainage.

MATERIALS & METHODS

In February 1992, 80 0.1 ha (31.6 m^2) plots were surveyed and permanently marked with iron stakes (Figure 6).

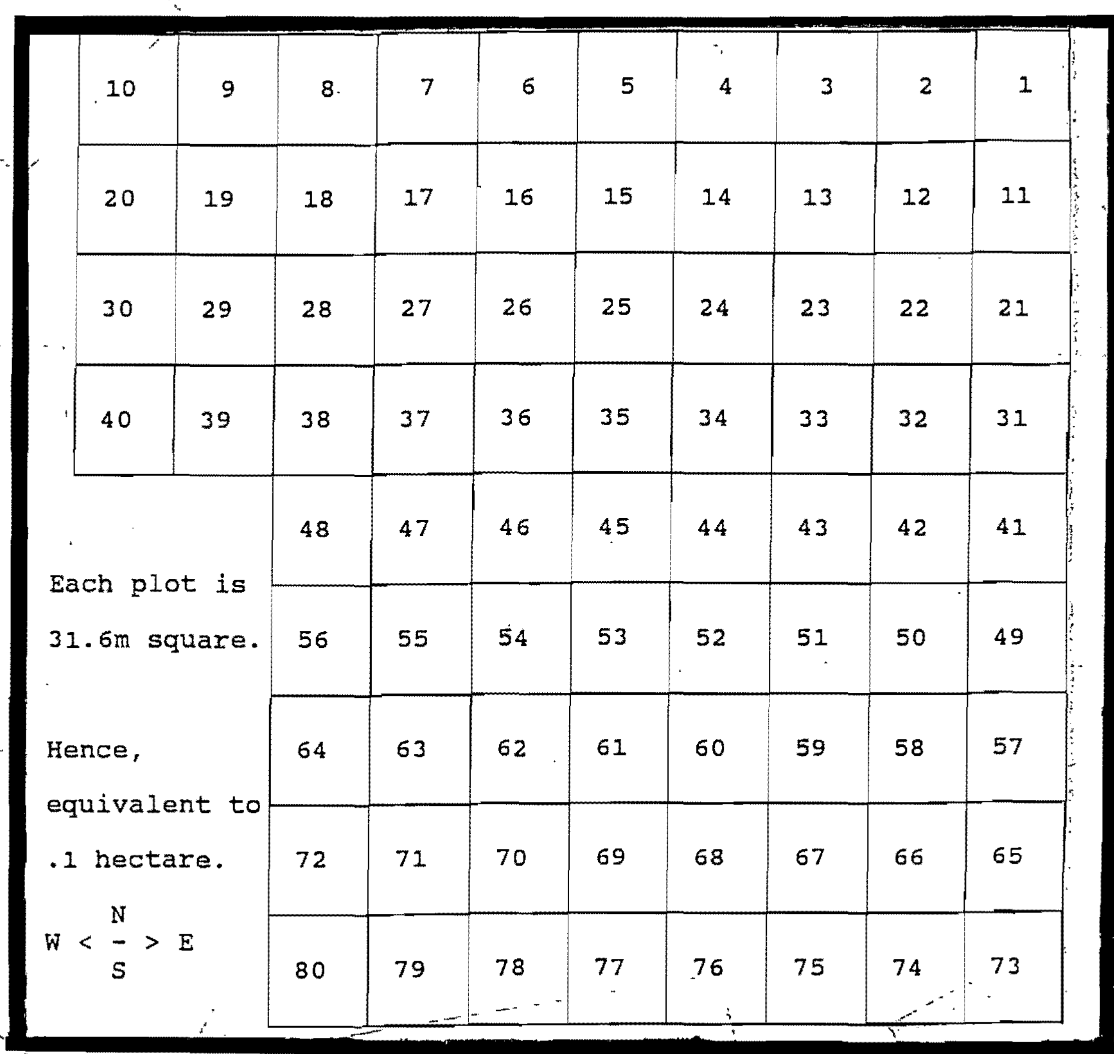

Figure 6. Plot layout of study area.

An east-west baseline was set along the north boundary, using a Sunto sighting compass and a surveyors transit. From the northeast corner, a straight line was drawn 31.6 m to the south, and an iron stake was inserted into the ground approximately one meter deep. From that same northeast corner another distance of 31.6 m was marked out to the west, and an iron stake was placed into the ground approximately one meter deep. The transit was then moved to the new west marking point and backsighted to the original northeast corner. From that point another 31.6 m was marked to the south, completing the first plot measuring 31.6 m^2. This same process was used to mark out the remaining plots. Iron fence posts two and three-quarters meters in length were buried approximately two meters deep to mark the six major corners of the study area.

In June 1992 a string line was laid down across each row of plots, dividing them into northern and southern halves. Then a pair of two-man teams with one data recorder moved along the grid line to the first tree over 10.0 cm dbh. Using the sighting compass, the researcher positioned himself directly north (or directly south) ninety degrees to the tree. The second researcher measured the distance out to the tree using a metal loggers tape. Then the diameter at breast height (dbh) was measured using a diameter tape, and the tree species was identified. East-West and North-South distances, dbh and species were recorded for the appropriate plot number. This process was repeated for each tree. All trees measuring 5.0 to 9.9 cm dbh were recorded by species. This was done throughout the remainder of the plots.

String lines were removed at the end of the project. Other than tree reproduction, spicebush and pawpaw most impeded vision in the surveying of lines; greenbriar (Smilax glauca), poison ivy (Rhus toxicodendron) and stinging nettel (Laportea canadensis) were particularly troublesome in walking and laying out tapes.

There were no storm tracts noted in either 1967 or 1992, but we did encounter several major openings from large windthrown or topped trees in various stages of ingrowth. These will be outlined in some detail in studies to follow. One notices, working during the summer, how little wind there is at ground level. The interior of this relatively large tract enjoys good protection from blowdown by typical windstorms.

Gary Carpenter of the Saint Meinrad College Math Department wrote the program for the IBM Clone Computer to generate tables of density, basal area, importance value, and size class data as well as maps of each plot. Each tree is represented by a circle of a size corresponding to its size class. The program can select any format of species, plots, or groups of species. All formats can be overlaid to compare and contrast the differences among them. The computer program is designed to accept data from decade interval studies to follow. The small map sheets will be used to locate trees in the field, and new data can be entered on them directly. Examples of a variety of formats will be found in Appendix A. One major benefit of this program is that it can be used for data from other stands, eliminating the problem of calculation error, and speeding up calculation time for the various charts and tables.

RESULTS & DISCUSSION

The study area included 39 species (Appendix B). There is some question whether the team was correct in not recognizing some southern red oak (Q. falcata) as cherrybark oak (Q. falcata var pagodaefolia). Species identification followed Little (1953). Size classes were measured in 10 cm size intervals. Stand density was 228 trees/ha. Stand basal area was 33 m^2/ha. Southern red and Shumard oaks contributed 53% of the stand basal area; the 6 other oaks accounted for 18%. Shellbark and shagbark hickories combined had 7% of the basal area, and sweetgum 9% (Table 1).

SPECIES	B_2	B_3	D_2	D_3	V_3
Southern Red Oak (Qf)	10	30	26	12	21
Shumard Oak (Qsh)	7.6	23	17	7.4	15
Sweet Gum (Ls)	2.9	8.7	13	5.7	7.2
Shellbark Hickory (Cl)	1.5	4.5	23	10	7.2
Shagbark (Co)	0.93	2.8	23	10	6.4
Swamp White Oak (Qb)	2.0	6.0	8.1	3.6	4.8
White Oak (Qa)	1.0	3.1	5.1	2.2	2.6
Pin Oak (Qp)	0.97	3.0	2.1	0.93	2.0
Swamp Chestnut Oak (Qmi)	0.93	2.8	5.2	2.3	2.6
Beech (Fg)	0.87	2.6	3.1	1.4	2.0
Red Oak (Qr)	0.79	2.4	3.1	1.4	1.9
American Elm (ua)	0.61	1.8	30	13	7.4
Blue Beech (Ccr)	0.47	1.4	12	5.1	3.2
Green Ash (Fp)	0.47	1.4	10	4.4	2.9
Red Maple (Ar)	0.44	1.3	5.6	2.5	1.9
White Ash (Fa)	0.26	0.78	9.2	4.0	2.4
Black Walnut (Jn)	0.17	0.51	1.0	0.44	0.48
Boxelder (Ane)	0.12	0.36	7.2	3.2	1.8
Black Gum (Ns)	0.11	0.30	1.0	0.44	0.37
Red Elm (Ur)	0.09	0.27	4.4	1.9	1.1
Hackberry (Coc)	0.08	0.24	4.4	1.9	1.1
Sugarberry (Clv)	0.08	0.24	4.0	1.8	1.0
Sugar Maple (As)	0.06	0.18	1.9	0.82	0.50
Cork (Rock) Elm (Ut)	0.04	0.12	3.1	1.4	0.76
Pignut Hickory (Cg)	0.02	0.06	1.0	0.44	0.25
Other Species	0.66	1.9	4.2	1.8	1.3

B_9 33.2 m^2/ha D_9 228 m^2/ha

Table 1. Kramer Woods 1992: Species attributes of trees >10cm (m^2/ha; #/ha).

American elm with the highest density of 30 trees/ha contributed little basal area. Southern red and Shumard oaks combined for 19% of stand density. Shellbark and shagbark hickories contributed 20%. Other species with at least 5 trees/ha were sweetgum, swamp white oak, white oak, swamp chestnut oak, blue beech, green ash, red maple, white ash, and boxelder.

Greatest impact according to importance values comes from southern red oak, shumard oak, shellbark/shagbark hickories, and sweetgum. The histogram illustrates graphically the role which each of the major species plays at present (Figure 7).

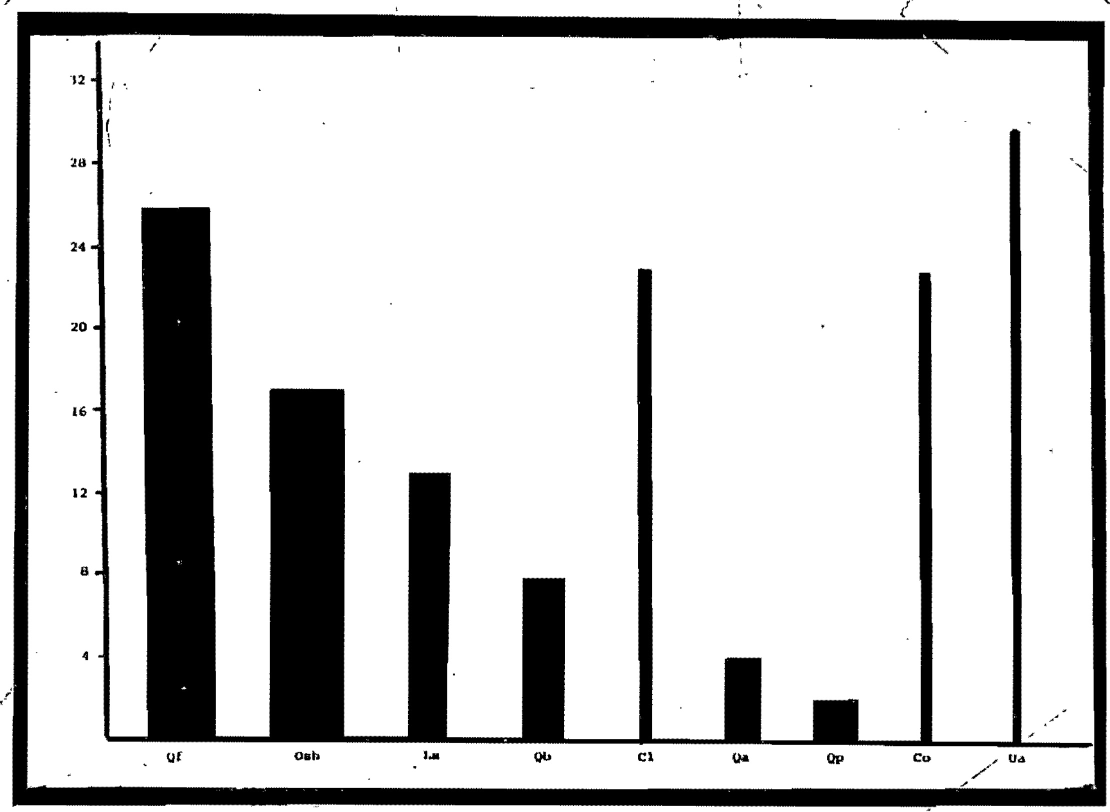

Figure 7. Histogram combining density (vertical axis) and average stem diameter (horizontal axis).

The size-class distribution chart (Table 2) further clarifies that the oak species, two of the hickories, and sweet gum are the major components of Kramer Woods. Of these the hickories are reproducing most successfully. Sweetgum, swamp white oak, and swamp chestnut oak show strong positions. White and green ash may become more important as time passes. American elm could be expected to remain abundant only in the smaller size-classes. Although there are some large beech, the site is wrong for it ever to become a significant species.

Slight differences in topographic elevation and resulting soil moisture conditions certainly are controlling factors for some species such as beech. Reproductive opportunities in windthrows in the recent or remote past is always a factor. Some of the depressions where water sits for extended periods in the spring were practically barren of vegetation.

In 1967 (Table 3) Shumard was the dominant oak, followed by pin oak. Southern red oak was fifth in importance out of the six oaks present. Bur oak and red oak were not tallied in 1967. In the comparison of the 1967 and 1992 data showed the Oak species were more similar than different. Shellbark and shagbark hickories as well as sweetgum were having about the same impact in the stand. American elm had the same high density/low basal area presence. Both stand basal area (29.3 m^2/ha) and stand density (196/ha) were somewhat less than in 1992.

Noting pronounced clustering of species, certain 0.1 ha plots had heavier concentrations of a particular species than other plots. This along with the fact that the 1967 and 1992 study areas were not identical even though there was considerable overlap would account for divergence of attributes among several key species.

	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140	10-140	0-140
Ane	93	48	7													55	148
Ar	14	23	10	8		1		1	1	1						45	59
As	7	9	4	2												15	22
At	191	4														4	195
Ccr	100	73	8	5	2	3	1	1								93	193
Cc	6															0	6
Cg	2	7	1													8	10
Cl	383	127	17	10	9	11	5	5		1						185	568
Co	173	131	28	10	7	5	3									184	357
Ct	1	2														2	3
Cs	1	1						1								2	3
Clv	92	31			1											32	124
Coc	71	31	3	1												35	106
Ccn	10	4														4	14
Dv		1	1													2	2
Fg	4	3	2		3	4	7	3	3							25	29
Fa	133	66	4	2		1			1							74	207
Fp	69	62	8		6	2	2	1								81	150
Jn				3	3	1	1									8	8
Ls	10	18	8	8	11	26	18	9	5	1						104	114
Lt		1								1						2	2
Mr	10	7														7	17
Ns	4	2	2	2	1		1									8	12
Pd							1									1	1
Po						2	2									4	4
Ps			1	1												2	2
Qa	4	17	6		2	5	2	3	2	2	1	1				41	45
Qb	13	23	11	4	3	2	5	2	5	7	1	1		1		65	78
Qf			1	4	29	47	47	39	20	14	6	2	2			211	211
Qma	2		1	1											1	3	5
Qmi	10	13	9	3	5	1	2	5	3		1					42	52
Qp	1				1	3	3	5	3		2					17	18
Qr	1	1	4	8	2	1	1	5	1	1	1					25	26
Qsh	1	2		10	5	22	19	23	36	9	6	1		1	2	136	137
Ua	210	209	24	6	1											240	450
Ur	46	31	2	1	1											35	81
Ut	114	24	1													25	139
Vi	2															0	2
TOTAL	1778	971	163	89	92	137	120	103	80	37	18	5	2	2	3	1822	3600
PER HA	222	121	20	11	12	17	15	13	10	4.6	2.2	0.62	0.25	0.25	0.38		

Table 2. Kramer Woods 1992: Size class distribution (0=5.0-9.9 cm; 10=10.0-19.9 cm; etc.)

SPECIES	B_2	B_3	D_2	D_3	V_3
Shumard Oak (Qsh)	8.7	30	35	17	23
Pin Oak (Qp)	3.9	13	11	5.4	9.2
Shellbark Hickory (Co) Shagbark Hickory (Cl)	3.2	10	32	16	13
Sweet Gum (Ls)	2.8	9.4	14	7.3	8.4
Swamp White Oak (Qb)	2.3	7.8	8.9	4.6	6.2
White Oak (Qa)	1.2	4.6	5.7	2.9	3.8
Southern Red Oak (Qf)	1.1	3.6	3.7	1.8	2.7
Beech (Fg)	0.94	3.2	3.0	1.6	2.4
American Elm (Ua)	0.80	2.7	24	12	7.4
Green Ash (Fp)	0.78	2.6	13	6.8	4.7
Swamp Chestnut Oak (Qmi)	0.61	2.1	3.7	1.9	2.0
Red Elm (Ur)	0.59	2.0	7.7	3.9	3.0
Red Maple (Ar)	0.52	1.8	5.4	2.8	2.3
Butternut Hickory (Cc)	0.32	1.1	4.9	2.6	1.8
Black Walnut (Jn)	0.29	0.99	2.7	1.4	1.2
Black Gum (Ns)	0.27	0.96	2.7	1.4	1.2
Pignut Hickory (Cg)	0.16	0.57	2.3	1.2	0.88
Boxelder (Ane)	0.10	0.35	2.7	1.4	0.88
Sugarberry (Clv)	0.05	0.17	1.2	0.59	0.38
Redbud (Ccn)	0.05	0.17	3.7	1.9	1.0
Blue Beech (Ccr)	0.02	0.07	2.1	1.1	0.59
Other Species	0.64	2.2	6.7	3.3	2.8

B_9 29.3 m^2/ha D_9 196 m^2/ha

Table 3. Kramer Woods 1967: Species attributes of trees ≥10cm (m^2/ha; #/ha).

Dutch elm disease surely affected this stand 40 years or so ago when it killed off most larger specimens of American elm in forests and cities. During the last 25 years it has remained numerous in the lowest size classes only. It is a prolific seed producer even when the trees are small, and survival is good in the understory.

The semi-log graph (Figure 8) shows a loss of trees in the 20-60 cm dbh size classes and gains in the larger size classes. The data are for the non-identical but overlapping areas, and so the lines do not precisely represent the change in the 25 year span. Future studies every decade will track such changes in distribution and perhaps help to clarify whether a relatively undisturbed stand is represented by a nearly straight line or a line with plateau in the middle size classes.

Future studies will compare Kramer Woods to other old-growth stands of similar types, e.g., Davis, Hemmer, and Wesselman Woods.

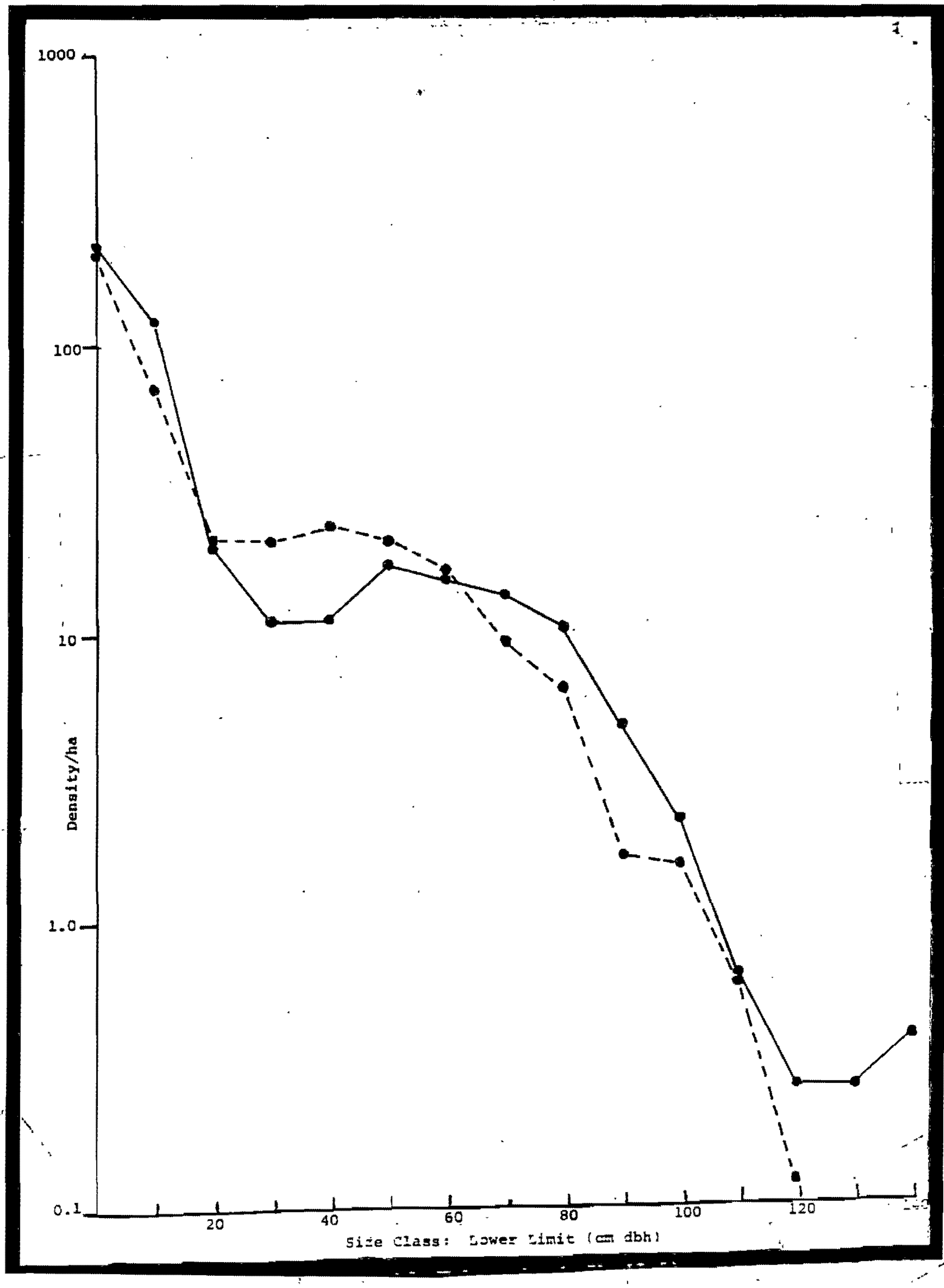

Figure 8. Kramer Woods: Size class distribution.
------ 1967 ____ 1992

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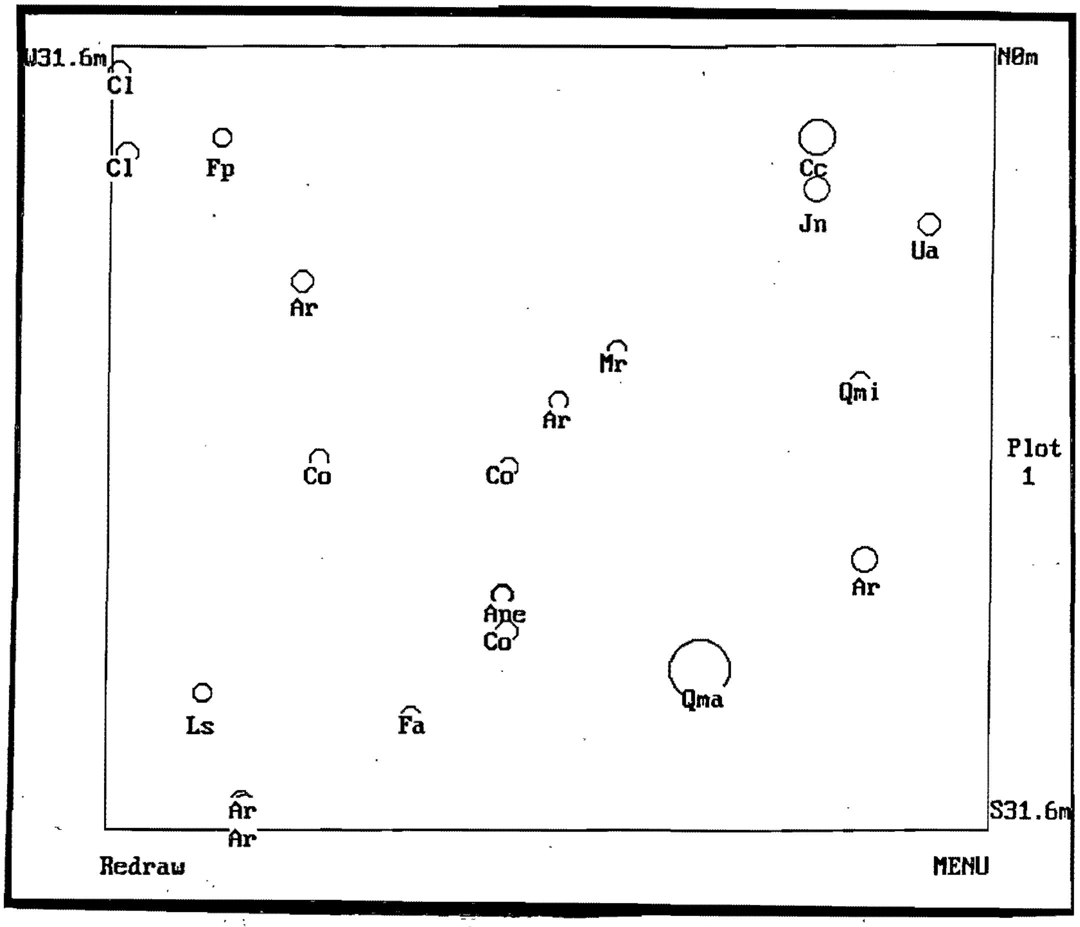
APPENDICES

APPENDIX A-1



Appendix A-1. Example of computer generated map of plot 1. This may be reproduced for all 80 plots.

APPENDIX A-2

Species	Count	Density Count/hectare D2	Relative Density Species Count/Stand Count D3
Ane	148	18.5000	0.0411
Ar	60	7.5000	0.0167
As	22	2.7500	0.0061
At	195	24.3750	0.0542
Ccr	204	25.5000	0.0567
Cc	0	0.0000	0.0000
Cg	10	1.2500	0.0028
Cl	566	70.7500	0.1572
Co	356	44.5000	0.0989
Ct	3	0.3750	0.0008
Cs	3	0.3750	0.0008
Clv	123	15.3750	0.0342
Coc	106	13.2500	0.0294
Ccn	10	1.2500	0.0028
Dv	2	0.2500	0.0006
Fg	29	3.6250	0.0081
Fa	206	25.7500	0.0572
Fp	152	19.0000	0.0422
Ft	2	0.2500	0.0006
Jn	8	1.0000	0.0022
Ls	114	14.2500	0.0317
Lt	2	0.2500	0.0006
Mr	18	2.2500	0.0050
Ns	12	1.5000	0.0033
Pd	1	0.1250	0.0003
Po	4	0.5000	0.0011
Ps	2	0.2500	0.0006
Qa	45	5.6250	0.0125
Qb	79	9.8750	0.0219
Qf	209	26.1250	0.0580
Qma	7	0.8750	0.0019
Qmi	52	6.5000	0.0144
Qp	17	2.1250	0.0047
Qr	26	3.2500	0.0072
Qsh	136	17.0000	0.0378
Ta	0	0.0000	0.0000
Ua	452	56.5000	0.1255
Ur	79	9.8750	0.0219
Ut	139	17.3750	0.0386
Vi	2	0.2500	0.0006

Stand Count is 3601
Stand Density (D9) is 450.1250 trees/hectare
for Plots number >>> ALL Plots (1-80)

Appendix A-2. Density chart for all plots (1-80). This may be reproduced for any plot(s), individual trees, or groups of trees.

APPENDIX A-3

Species	Basal Area cm²/hectare B2	Relative Basal Area B2 ÷ B9 B3
Ane	1459.4640	0.0044
Ar	4290.3310	0.0128
As	635.8762	0.0019
At	512.1763	0.0015
Ccr	5010.8350	0.0150
Cc	0.0000	0.0000
Cg	163.0675	0.0005
Cl	15650.7100	0.0468
Co	9682.4780	0.0289
Ct	50.8538	0.0002
Cs	616.3400	0.0018
Clv	909.1950	0.0027
Coc	996.6688	0.0030
Ccn	101.7087	0.0003
Dv	66.3650	0.0002
Fg	8738.0370	0.0261
Fa	2912.8430	0.0087
Fp	5004.2570	0.0150
Ft	96.8000	0.0003
Jn	1723.2600	0.0052
Ls	28766.0700	0.0860
Lt	937.8625	0.0028
Mr	200.5700	0.0006
Ns	1079.9210	0.0032
Pd	453.9587	0.0014
Po	1489.4070	0.0045
Ps	161.0063	0.0005
Qa	10344.0800	0.0309
Qb	19909.7300	0.0595
Qf	99492.9800	0.2974
Qma	2252.7160	0.0067
Qmi	9253.5530	0.0277
Qp	9582.6340	0.0286
Qr	7966.7770	0.0238
Qsh	75691.2100	0.2262
Ta	0.0000	0.0000
Ua	6628.6560	0.0198
Ur	1045.2650	0.0031
Ut	709.1150	0.0021
Vi	4.9075	0.0000

Stand Basal Area (B9) is 334591.7000 cm²/hectare
for Plots number >>> ALL Plots (1-80)

Appendix A-3. Basal-area chart for all plots (1-80). This may be reproduced for any plot(s), individual trees, or groups of trees.

APPENDIX A-4

	0	10	20	30	40	50	60	70	80	90	100	110	120	130	140cm	Totals
Ane	93	46	8	1												148
Ar	16	24	10	6		1		1	1	1						60
As	7	9	4	2												22
At	191	4														195
Ccr	111	72	9	4	3	2	2	1								204
Cc																0
Cg	2	7	1													10
Cl	382	126	19	8	9	10	6	4	1	1						566
Co	172	130	29	9	8	5	3									356
Ct	1	2														3
Cs	1	1						1								3
Clv	91	31			1											123
Coc	71	31	3	1												106
Ccn	6	4														10
Dv		1	1													2
Fg	4	3	2		2	5	7	3	3							29
Fa	132	66	4	2		1			1							206
Fp	70	62	9		6	2	2	1								152
Ft	1			1												2
Jn				3	1	3	1									8
Ls	10	17	9	8	11	26	17	10	5	1						114
Lt		1								1						2
Mr	11	7														18
Ns	4	2	2	2	1		1									12
Pd							1									1
Po						2	2									4
Ps			1	1												2
Qa	4	17	6		2	5	2	3	2	2	1	1				45
Qb	14	22	11	5	3	2	4	3	5	5	3	1		1		79
Qf			1	2	26	46	48	40	22	13	7	2	2			209
Qma	4		1	1											1	7
Qmi	10	13	9	3	4	2	2	5	2	1	1					52
Qp					1	3	3	5	2	1	1	1				17
Qr	1	1	4	7	2	2	1	5	1	1	1					26
Qsh	1	2	1	7	6	20	20	24	35	10	6	1		1	2	136
Ta																0
Ua	212	208	25	5	2											452
Ur	44	31	2	1	1											79
Ut	114	24	1													139
Vi	2															2
Totals:	1782	964	172	79	89	137	122	106	80	37	20	6	2	2	3	3601

For Plots number >>> ALL Plots (1-80)

Appendix A-4. Diameter chart for all plots (1-80). This may be reproduced for any plot(s), individual tree(s), divided into sub-canopy (diameters 10-30 cm) or canopy (diameter 40-140 cm), groups of trees. The 0 diameter column signifies all trees >9.9 cm dbh.

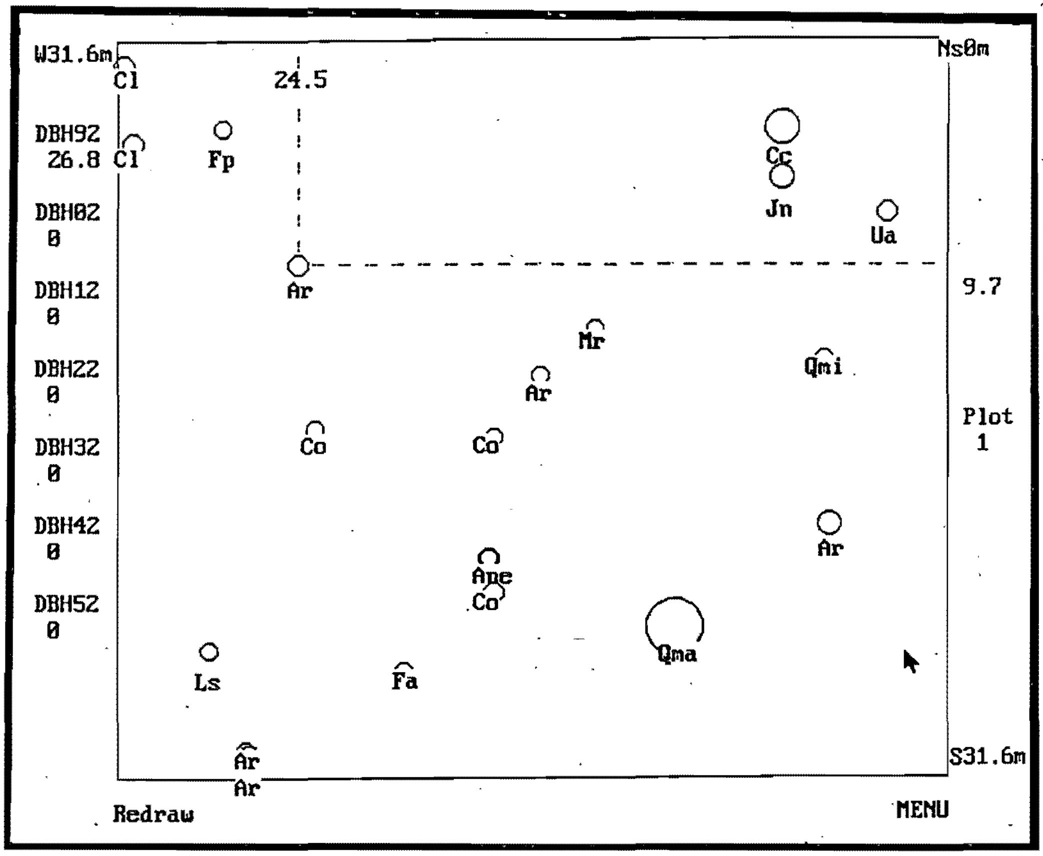
APPENDIX A-5

Species	Relative Density Species Count/Stand Count D3	Relative Basal Area B2 ÷ B9 B3	(D3 + B3) ÷ 2 Importance
Ane	0.0411	0.0044	0.0227
Ar	0.0167	0.0128	0.0147
As	0.0061	0.0019	0.0040
At	0.0542	0.0015	0.0278
Ccr	0.0567	0.0150	0.0358
Cc	0.0000	0.0000	0.0000
Cg	0.0028	0.0005	0.0016
Cl	0.1572	0.0468	0.1020
Co	0.0989	0.0289	0.0639
Ct	0.0008	0.0002	0.0005
Cs	0.0008	0.0018	0.0013
Clv	0.0342	0.0027	0.0184
Coc	0.0294	0.0030	0.0162
Ccn	0.0028	0.0003	0.0015
Dv	0.0006	0.0002	0.0004
Fg	0.0081	0.0261	0.0171
Fa	0.0572	0.0087	0.0330
Fp	0.0422	0.0150	0.0286
Ft	0.0006	0.0003	0.0004
Jn	0.0022	0.0052	0.0037
Ls	0.0317	0.0860	0.0588
Lt	0.0006	0.0028	0.0017
Mr	0.0050	0.0006	0.0028
Ns	0.0033	0.0032	0.0033
Pd	0.0003	0.0014	0.0008
Po	0.0011	0.0045	0.0028
Ps	0.0006	0.0005	0.0005
Qa	0.0125	0.0309	0.0217
Qb	0.0219	0.0595	0.0407
Qf	0.0580	0.2974	0.1777
Qma	0.0019	0.0067	0.0043
Qmi	0.0144	0.0277	0.0210
Qp	0.0047	0.0286	0.0167
Qr	0.0072	0.0238	0.0155
Qsh	0.0378	0.2262	0.1320
Ta	0.0000	0.0000	0.0000
Ua	0.1255	0.0198	0.0727
Ur	0.0219	0.0031	0.0125
Ut	0.0386	0.0021	0.0204
Vi	0.0006	0.0000	0.0003

For Plots number >>> ALL Plots (1-80)

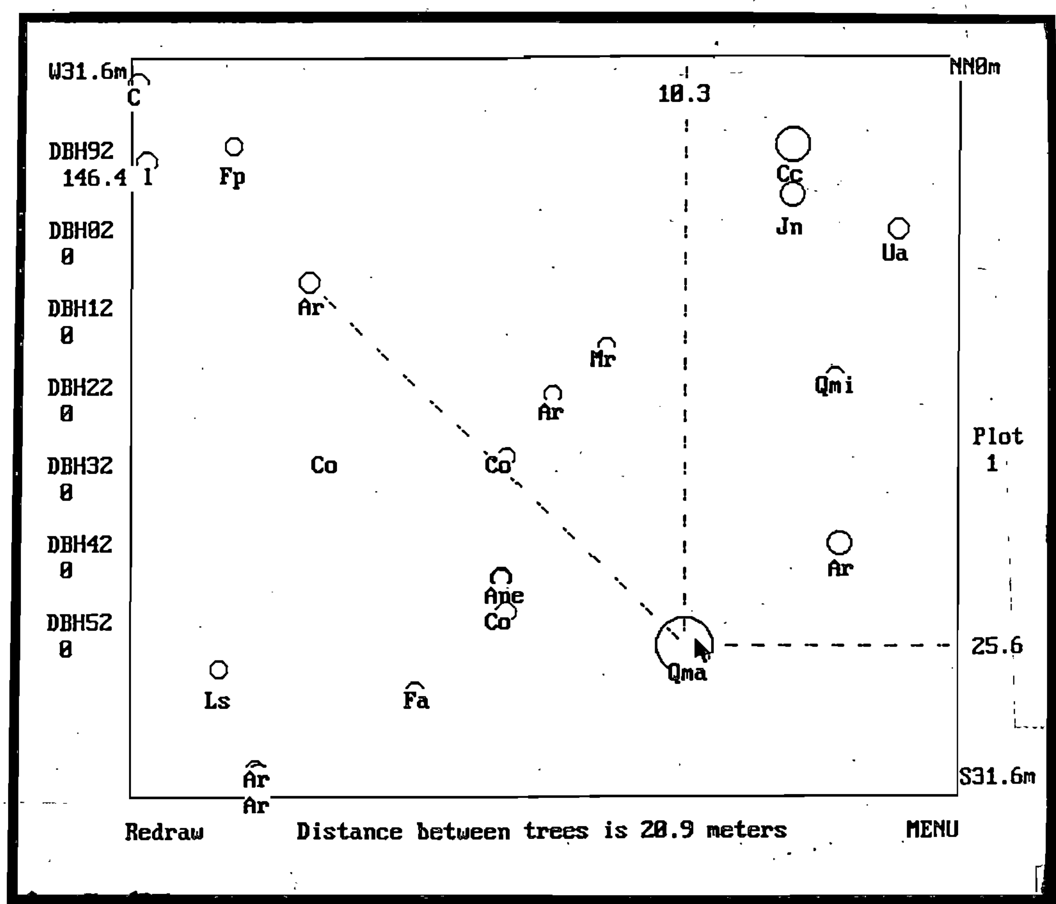
Appendix A-5. Importance chart for all plots (1-80). This may be reproduced for any plot(s), individual trees, or groups of trees.

APPENDIX A-6



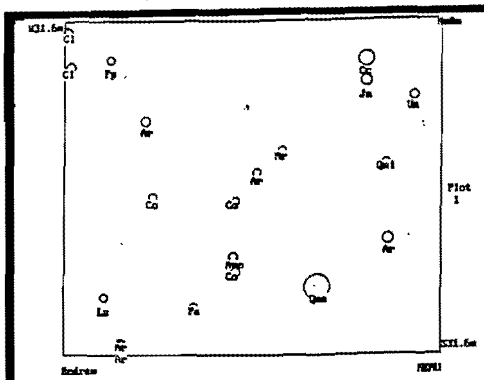
Appendix A-6. Computer generated plot layout showing distances from plot borderlines to any specific tree. Also included is the dbh measurements in ten year increments to monitor tree growth. May be reproduced for any plot(s).

APPENDIX A-7



Appendix A-7. Computer generated plot layout showing distances from plot borderlines to any specific tree, also showing distances between two trees. Also included is the dbh measurements in ten year increments to monitor tree growth. May be reproduced for any plot(s).

APPENDIX A-8



Plot #	S/N	W/E	Species	1992	2002	2012
1	0.0	0.0	Cl			
1	0.0	0.0	Cl			
1	0.0	0.0	Cl			
1	0.0	0.0	Qm			
1	0.0	0.0	Qm			
1	0.0	0.0	Cl			
1	0.0	0.0	Cl			
1	0.0	0.0	At			
1	0.0	0.0	Cl			
1	0.0	0.0	Cl			
1	0.0	0.0	Cl			
1	0.0	0.0	Cl			
1	0.0	0.0	Coc			
1	0.0	0.0	Qb			
1	0.0	0.0	Qb			
1	0.0	0.0	Coc			
1	0.0	0.0	Ar			
1	0.0	0.0	Ar			
1	0.0	0.0	At			
1	0.0	0.0	Coc			
1	0.0	0.0	At			
1	0.0	0.0	Ns			
1	1.1	31.0	Cl	26.8		
1	3.8	27.4	Fp	12.4		
1	3.8	6.3	Cc	59.8		
1	4.4	30.7	Cl	21.2		
1	5.9	6.3	Jn	34.4		
1	7.4	2.3	Ua	23.7		
1	9.7	24.5	Ar	26.8		
1	12.5	13:3	Mr	18.6		
1	13.8	4.7	Qmi	18.0		
1	14.6	15.4	Ar	13.7		
1	16.9	23.9	Co	10.4		
1	17.3	17.1	Co	14.6		
1	21.1	4.5	Ar	37.5		
1	22.6	17.3	Ane	17.2		
1	22.6	17.3	Ane	21.2		
1	24.1	17.1	Co	19.8		
1	25.6	10.3	Qma	146.4		
1	26.6	27.9	Ls	10.2		
1	27.5	20.5	Fa	10.1		
1	31.0	26.5	Ar	20.5		
1	31.2	26.4	Ar	30.6		

Appendix A-8. Computer generated data input sheet showing all trees for a selected plot, including their dbh measurements in ten year increments. Trees showing no dbh fall in to the >9.9cm category. May be reproduced for any plot(s).

APPENDIX A-9

Ane	Acer Negundo, L.	Boxelder
Ar	A. rubrum var. rubrum	Red maple
As	A. saccharum Marsh.	Sugar maple
At	Asimina triloba (L.) Dunal	Pawpaw
Ccr	Carpinus caroliniana Walt.	Blue beech
Cc	Carya cordiformis (Wangenh.) K. Koch.	Bitternut hickory
Cg	C. glabra var. glabra	Pignut hickory
Cl	C. laciniosa (Michx. f.) Loud.	Shellbark hickory
Co	C. ovata (Mill.) K. Koch	Shagbark hickory
Ct	C. tomentosa Nutt.	Mockernut hickory
Cs	Catalpa speciosa Warder	Catalpa
Clv	Celtis laevigata Willd.	Sugarberry
Coc	C. occidentalis L.	Hackberry
Ccn	Cercis canadensis var. canadensis	Redbud
Dv	Diospyros virginiana car. virginiana	Persimmon
Fg	Fagus grandifolia Ehrh.	Beech
Fa	Fraxinus americana L.	White ash
Fp	F. pennsylvanica Marsh.	Green ash
Ft	F. tomentosa	Ash
Jn	Juglans nigra L.	Black walnut
Ls	Liquidambar styraciflua L.	Sweet gum
Lt	Liriodendron tulipifera L.	Tuliptree
Mr	Morus rubra L.	Red mulberry
Ns	Nyssa sylvatica var. sylvatica	Black gum
Pd	Populus deltoides Bartr.	Cottonwood
Po	Platanus occidentalis L.	Sycamore
Ps	Prunus serotina var. serotina	Wild black cherry
Qa	Quercus alba L.	White oak
Qb	Q. bicolor Willd.	Swamp white oak
Qf	Q. falcata var falcata	Southern red oak
Qma	Q. macrocarpa Michx.	Bur oak
Qmi	Q. Michauxii Nutt.	Swamp chestnut oak
Qp	Q. palustris Muenchh.	Pin oak
Qr	Q. rubrum.	Red oak
Qsh	Q. shumardii var. shumardii	Shumard oak
Ta	Tilia americana L.	Basswood
Ua	Ulmus americana var. americana	American elm
Ur	U. rubra Muhl.	Red elm
Ut	U. thomasi Sarg.	Cork (rock) elm
Vi	Vitis sp.	Grape

Appendix A-9. Kramer Woods 1992: Key to species.